Analysis of bidirectional buck boost converter by using PWM control scheme

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Abstract-
To obtain a stable voltage from an input supply that is higher and lower than the output, a high efficiency and minimum ripple DC-DC converter is required in many applications such as hybrid vehicle, fuel cell vehicle, and renewable energy system. Buck-boost converters makes it possible to efficiently convert a DC voltage to either a lower or higher required voltage. This paper deals with simulation of Bidirectional buck boost converter. Bidirectional buck-boost converters and its control method are proposed based on a new concept in which the proposed circuits uses PWM signal to control the MOSFET switch.

***Index terms*-Pulse width modulation (PWM) control scheme, Analysis and simulation**

I. INTRODUCTION

The buck boost converter is a type of DC-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. The output voltage is adjustable based on duty cycle of switching MOSFET. In addition to that Bi-Directional buck boost converter also provides reversal of power flow. The power can flow from input side to output side and also it can flow from output side to input side by using bidirectional feature of this converter.

Most of the existing bidirectional dc-dc converters fall into the generic circuit structure illustrated in Figure (1), which is characterized by a current fed or voltage fed on one side. Based on the placement of the auxiliary energy storage, the bidirectional dc-dc converter can be categorized into buck and boost type. The buck type is to have energy storage placed on the high voltage side, and the boost type is to have it placed on the low voltage side.

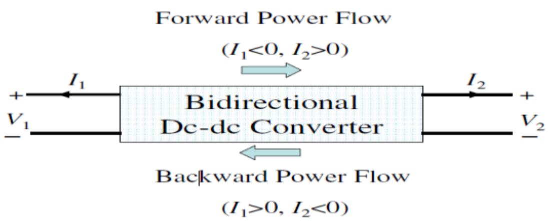


Fig.1 Illustration of bidirectional power flow

The bidirectional dc-dc converter along with energy storage has become a promising option for many power related systems, including hybrid vehicle, fuel cell vehicle, and renewable energy system. It not only reduces the cost and improves efficiency, but also improves the performance of the system. In the electric vehicle applications, an auxiliary energy storage battery absorbs the regenerated energy fed back by the electric machine. In addition, bidirectional dc-dc converter is also required to draw power from the auxiliary battery to boost the high-voltage bus during vehicle starting, accelerate and hill climbing.

There are basically two possible topologies of Bidirectional Buck Boost Converter. Each of them allows stepping the battery voltage level either up or down, according to motor drive mode of operation. The first topology is derived from the traditional buck boost scheme by introducing a dual switch diode power module.

II. PROPOSED BIDIRECTIONAL BUCK BOOST CONVERTER

Figure (2) shows the equivalent circuit of a bidirectional buck-boost converter. In this converter switches T1 and T2 are operated to accomplished forward power flow and switches T3 and T4 are for reverse power flow. In forward power mode of operation there is two modes step up and step down. Switch T1 is only operated for step down mode and all other switch are off. Whereas T2 is for step up mode. So whenever stepping up of battery level is needed T2 is operated and T1 is permanently in on state. Similarly reverse power mode of operation there is two mode step up and step down T3 and T4 are modulated in similar manner for reverse power mode of operation.

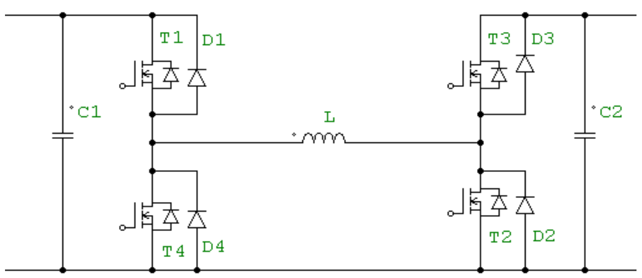
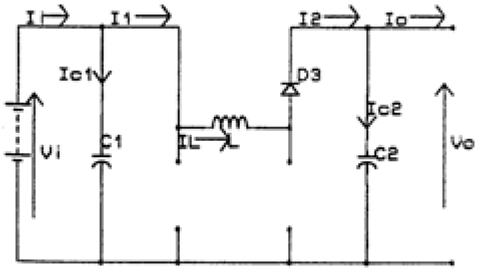


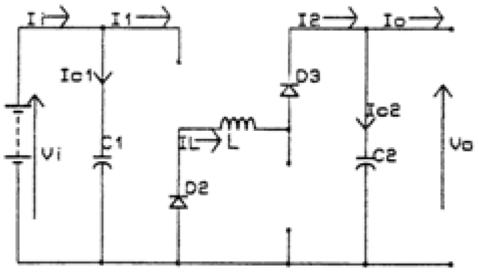
Fig. 2 Proposed Bi-Directional Buck-Boost Converter

OPERATION OF PROPOSED BIDIRECTIONAL BUCK BOOST CONVERTER

In this converter arrangement only the switch T1 is operated to accomplish forward power mode of operation with stepping down the battery voltage. The diode D2 is always reverse biased and D3 is direct biased alone the entire period of operation. As shown in figure (3) When switch T1 is on, the battery supplied energy to the inductor L and to the load, whereas switch T1 being in the off state. The diode D4 is direct biased and the load receives energy from the inductor.



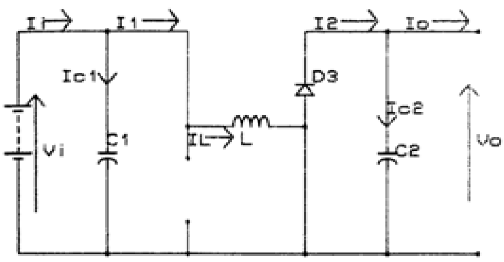
(a)



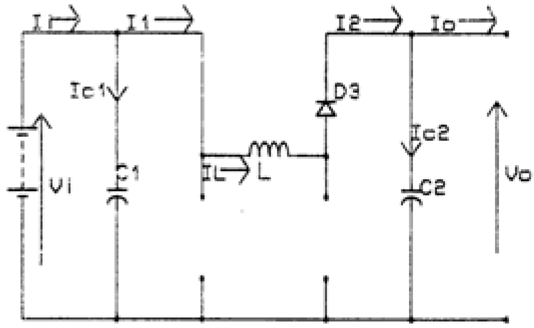
(b)

Fig 3 Bi-directional Buck-boost Converter in step –down mode (a) Switch on (b) switch off

In forward power step up mode of operation, the switch T1 must be always on and T2 is operated with variable duty cycle according to motor speed. The switches T3 and T4 are steadily off and the diode D4 is reversed biased at that time as shown in figure (4). When switch T2 is on, the battery supplies energy to the inductor while the load receives energy from the capacitor C2.As T2 is off, the diode D3 is direct biased load, and C2 receive energy from the inductor.



(a)



(b)

Fig. 4 Bi-directional Buck-boost Converter in Step–Up Mode (a) Switch on (b) Switch off

Similarly for reverse power mode, switch T3 is turned on for step down and T4 is turned on for step up.

III. PWM CONTROL SCHEME

In DC-DC converter, the average dc output voltage must be controlled to equal a desired level, through the input voltage and output may fluctuate. In a DC-DC converter with a given input voltage, the average output voltage is controlled by controlling the switch on and off durations. One of the methods for controlling the output voltage employs switching at a constant frequency and adjusting the on duration of the switch to control the average output voltage. In this method, called pulse width modulation (PWM) switching, the duty ratio D, which is defined as the ratio of the on duration to the switching time period, is varied.

Variation in the switching frequency makes it difficult to filter the ripple components in the input and output waveforms of the converter. In the PWM method which is switching at a constant frequency, the switch control signal, which controls the state of switch, is generated by comparing a signal level control voltage with a repetitive waveform.

The frequency of the repetitive waveform with a constant peak, establishes the switching frequency. This frequency is kept constant in a PWM control and is chosen to be in a few kilohertz to few hundred kilohertz range. The comparator output is high when the repetitive signal is greater than control signal otherwise output is zero.

IV. SIMULATION CIRCUITS OF BIDIRECTIONAL BUCKBOOST CONVERTER

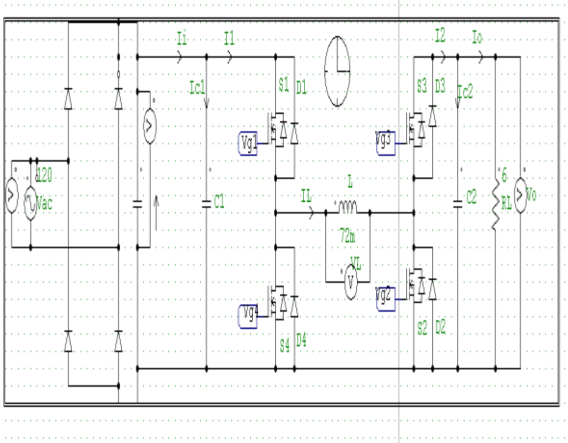


Fig. 5 Circuits of Bidirectional Buck-Boost Cascade Converter

SIMULATION OF BIDIRECTIONAL BUCK BOOST CONVERTER

Simulation of both forward and reverse power step up and step down mode of operation are done using PSIM software. The simulation is done using PSIM and results are presented here for boost and buck mode. Figure 5 shows the simulation circuit for buck mode with resistor as a load. Figure 6 shows the gate pulses for buck mode. Figure 7 shows output waveform with input voltage of 120 V for buck mode. Figure 9 shows the gate pulses for boost mode. Figure 10 Shows output waveform of input voltage of 120 V.

Forward power step-down mode of operation

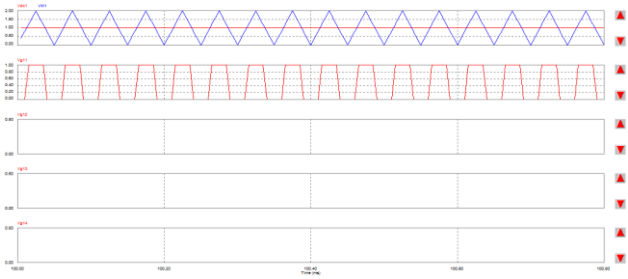


Fig. 6 Triangular wave comparison and Control Signal given to the Converter

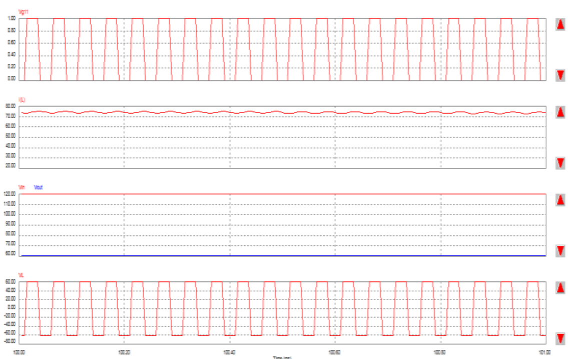


Fig. 7 Waveforms of gate pulse vg1, inductor current, input Voltage (Vi), output voltage, inductor Voltage (VL)

Forward power step-up mode of operation

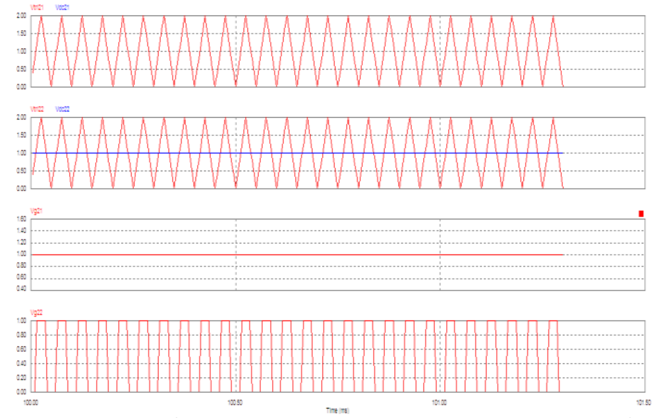


Fig.8 comparison of triangular wave with Dc level And control signal for Switch 1 and switch 2

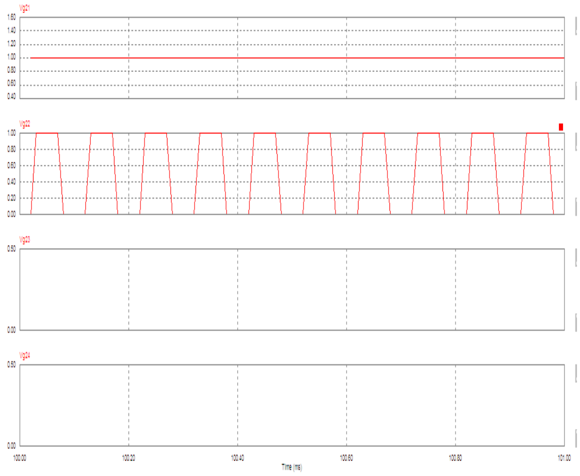


Fig. 9 Control Signal given to the Converter for step-up mode

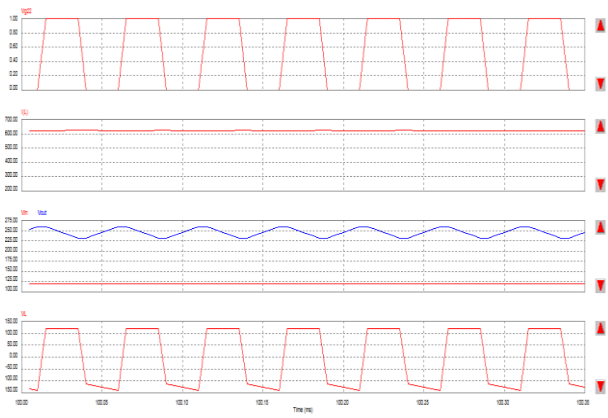


Fig.10 waveform of gate pulse, Inductor Current (IL), input voltage, output voltage, Inductor Voltage (VL)

V. CONCLUSION

The Bidirectional DC-DC converter is simulated using PSIM Software. It has a wide input voltage range. The results are presented for boost mode and buck mode. This converter can operate with a soft switching, a continuous inductor current and fixed switching frequency and low switch stresses.

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